Functional Bracing of the Upper Extremity

EDWIN R. SCHOTTSTAEDT, *M.D.*, MARGARET MAGEE, *R.P.T.*, and ELIZABETH PARRISH, *R.P.T.*, San Francisco, and GEORGE B. ROBINSON, *Prosthetist*, Vallejo

• **Arm bracing problems, because of their complexity, need careful evaluation by a team of interested specialists in the field of medicine, physical therapy, occupational therapy, orthotics or prosthetics. The patient must always be a working member of this team. If the basic principles of evaluation, fabrication and training are followed and the motivation is good, success with specific goals may be expected.**

A few arm brace situations as they reflect special problems are discussed in the hope of stimulating more interest in this fascinating field.

FUNCTIONAL ARM BRACING is an established tool in the armamentarium of the upper extremity prosthetist and the accomplished orthotist. However, the subject is not generally well understood.

Since the purpose of such bracing is to replace or reinforce lost motion, it is necessary to know the relative importance of upper extremity motions in functional arm use.

In order of their functional importance, these movements may be listed as *grasp, elbow flexion, forward flexion of the humerus, shoulder rotation, pronation and supination, trunk motion or stability, wrist extension and flexion, shoulder abduction, elbow extension* and *humeral extension.* It should be noted that many times stability is the functional equivalent of motion, especially if the stable position can be varied. This is most commonly seen in arthrodesis of a wrist, which holds the wrist in a position of function that permits better use of the hand, and in an elbow-lock for a fixed elbow position with an above-elbow prosthesis. In certain situations gravity can be used to provide necessary motions. It can be used for elbow extension, for example, and the position of extension can be varied by the resistance of the elbow flexors throughout different portions of the range. Gravity is of great assistance in providing pronation and it also provides the return to neutral from humeral forward flexion. The movements decided upon for replacement will depend upon a careful analysis of the patient and his proposed activities.

At the outset, emphasis should be placed upon the concept that success will depend on the cooperative evaluation, prescription and training of the arm-bracing team. This team must include the physician, therapist, prosthetist or orthotist and, last but not least, the patient himself. The physician must be responsible for the proper evaluation of the disease process, its possible progression and the work tolerance of the patient. The therapist must train the patient after the apparatus is provided and assist in the brace prescription. The prosthetist or orthotist must provide adequate, properly fitting and properly harnessed bracing, and the patient must provide motivation and effort to make the bracing work properly. For successful prescription, the patient must have some insight into his fundamental functional needs, and these needs must be respected by other members of the team, else the patient cannot be expected to maintain his motivation or to continue wearing a brace even if he should succeed in learning to use it. The chief factors of importance in evaluation of the patient can be divided into the following categories for more detailed discussion. They include:

- Evaluation of motor ability and disability.
- Evaluation of perceptual ability.
- Analysis of functional needs in their relative importance.
- Estimation of patient's "gadget tolerance."
- Estimation of patient's neuromuscular ability (coordination level).
- Estimation of patient's motivation.

Evaluation of motor ability (chiefly a physical examination)

In examining the patient, use of a muscle chart of standard type tends to make recording of the information complete and more precise than a running commentary, although the addition of a running commentary may add many important items not recorded on the standard muscle chart form. The range of motion of upper extremity joints should be recorded, for this will tell whether certain activities are possible, regardless of muscle strength. The information gained from examination of range of motion and muscular function is of importance to indicate that a joint can be moved through a certain range with a given force.

The authors wish to express their appreciation to the Veterans Administration, San Francisco Office, for its cooperation in allowing us to use cases under its jurisdiction, and especially to Mr. Philip Bray, Chief of Prosthetic Service, and Miss Lynn Ahrens, R.P.T., for their help.

Presented before the Section on Orthopedics at the 90th Annual Session of the California Medical Association, Los Angeles, April 30 to May 3, 1961.

Evaluation of perceptual ability

It is important to know whether sensation is altered, since hypothesia or anesthesia may preclude use of certain brace apparatus, especially as it relates to grasp, and may prevent the patient's use of certain tools or equipment on a job. Of prime importance in brain damaged patients is an awareness of the involved extremity. It is essential that the team realize that a patient may not know where his hands and arms are in space unless he can watch them. He may be able to hold an object by voluntary closing of his hand or in a braced hand closed by motor power harnessed from the opposite and normal side, but unless he maintains conscious voluntary effort he may forget that he is holding something, and drop it.

It is also important in dealing with brain damaged patients to study voluntary range and the speed of voluntary control. Tremor, often an important factor in these patients, may be brought about and intensified in the hand and arm by concentrated effort on attempted use. To be successful, bracing for these patients must be kept to a minimum.

Analysis of functional needs and their relative importance

The patient has various functional needs which are easily determined by a comprehensive functional activity test and further elaborated by direct questioning of the patient. It is essential to recognize from the outset that arm bracing can never completely replace lost function, and that in replacing the most necessary functions, others may have to be foregone. Only the patient can know what he needs to accomplish most, and as nearly as possible the apparatus used to provide function must be designed to serve those needs. In the training program it is important that these be stressed.

Estimation of patient's "gadget tolerance"

In general, bracing should be kept to the minimum that will achieve the function decided upon. Additional brace equipment that adds only a little to function will probably be discarded eventually. It is important that the team estimate the patient's ability to wear the proposed bracing, his attitude toward it from a cosmetic point of view, his attention span and his willingness and ability to put up with minor and sometimes moderate inconvenience to attain his stated goal. This ability to wear equipment having varying degrees of complexity varies greatly between persons. Obviously a person who would be constantly frustrated by complicated equipment should not have it.

Coordination level

Some persons naturally have a fine sense of balance and easily learn to operate complicated mechanical apparatus, while others are hopelessly befuddled by even very simple equipment. All persons of average intelligence are able to learn to use arm-brace equipment satisfactorily, provided they have the will to do so, but the training period will vary depending on the natural coordinative ability of the patient.

Motivation

In the long run, the will to make good use of bracing apparatus lies in the patient himself. However, his attitude may be bolstered by the therapist and other members of the team. The long term use of brace equipment depends on the patient's need to accomplish certain functions and his willingness to put up with inconvenience to attain his goal. Choosing the proper brace for the patient and the condition is not always easy, even with careful prebracing evaluation. It may be necessary to change the harnessing or modify the brace construction as continuing contact with the patient emphasizes that the original conception represents an inadequate prescription for the patient's needs and falls short of real solution to the problem. One needs to keep his mind open to suggestions from the patient or other team members to accomplish optimum prescription and training proficiency. Thorough, supervised training in proper use of arm-brace equipment is mandatory, with the possible exception of such simple equipment as a tenodesis splint, and even here it is necessary that the patient understand the brace and how it works. Without supervision patients may learn to use a brace that has been well prescribed, but usually they develop bad use habits and often fail to realize the full potential of their equipment. The more complicated the apparatus, the more essential the need for training. Furthermore, a period of training under the direction of competent personnel allows an evaluation of the use, which often results in minor alterations of the brace and harness.

Effective arm-bracing prescription is more difficult than prescribing upper extremity prosthesis, for the arm proximal to the prosthetic device usually is properly stabilized or not damaged at all whereas usually in arm-bracing there is need to provide for stability of movement along the entire upper extremity kinetic chain. If the extremity is *flail*, grasp, elbow and shoulder motions must be considered and planned for appropriately. In such cases the remaining arm is used as a scaffolding and replacement or assistance is provided in multiple sites, as needed for function.

If there is only one joint in need of functional replacement or brace assistance, the task is relatively simple. The more brace segments needed, the greater the complexity of equipment and the more difficult the task of training. Good understanding of the patient's functional needs is of paramount importance, for the brace cannot restore all the normal

abilities and choices have to be made. The appearance and weight of the apparatus is important to the wearer. It must not be too heavy to make wearing it tiring and uncomfortable. It should be acceptable cosmetically and, if possible, it should be worn under the clothing.

An ambulatory patient should be able to carry the equipment on his body. If the patient is wheelchair-bound, one can occasionally attach the equipment to the wheelchair or to some structure—a worktable, for example—in the area in which it is to be used.

Some observers have criticized arm-bracing on the ground that patients may discard the apparatus after a few years. Sometimes the reason is that the brace was a failure functionally and never fitted the patient's needs. In some cases, however, the patient may simply have become stronger or have found better ways of accomplishing the activity the brace was intended for. This is also true of leg-bracing, and discard of braces on the legs is usually applauded. It should be borne in mind that without proper bracing, there can be no start in the activity; with it, the activity becomes possible and gradually more easily accomplished. Of course, in some instances, the brace is permanently worn for the activities it was designed to accomplish. Occasional reevaluation is necessary, for patients' needs change, and also brace concepts and techniques improve as experience is gained. With reevaluation, proper brace adjustment or improvement may be made. Although not essential, it is helpful if the patient can put the equipment on and take it off. He should at least be able to take it off.

HARNESS

Proper harnessing, which is essential for brace utilization can be accomplished in many different ways, the way depending upon the circumstances.

The sources of motion are varied and include:

- Elastic supplemental force working against a remaining voluntary motion or gravity.
- Axillary loops, or axillary and humeral loops, or bilateral humeral loops.
- Chest-strap control, taking advantage of scapular retraction, protraction and elevation in combination with humeral forward flexion associated with contraction of the pectoralis major and other muscles of the chest.
- A perineal strap attached to a reaction point on the same or opposite shoulder.
- Nudge control, using chin and neck motion.
- Trunk flexion and extension and lateral bending.
- Normal knee, hip, ankle and foot voluntary range of motion transfer by direct control through a Bowden cable housing or through a reciprocating device.

There are five main categories or types of brace problems that confront the arm-brace team.

1. Flaccid paralysis with normal sensation, as in poliomyelitis and damaged motor nerves

Patients in this category have normal mentality, space perception and sensation, but they may have joint contracture and muscle contracture as well as paralysis. There may be total upper extremity paralysis, but usually some function remains, and often this can be augmented by proper functioning brace prescription and training. In general, grasp is more satisfactorily accomplished in this group by using hand braces rather than hooks. The sensation and friction of the skin of the hand can be used. The normal skin friction makes much less force necessary to accomplish functional grasp. The wrist is stabilized unless residual motor power is available there. Elbow function is gained through locking stability, by flexion assisted by rubber bands against gravity or by harnessing power from unaffected or nearly normal muscle function. Forward flexion of the shoulder is usually provided by rubber band tension, and shoulder rotation by the use of a friction swivel control unless the extremity falls into the useful position without such aid.

2. Flaccid paralysis with decreased or absent sensation, as typified by brachial plexus injury

Here there is need to provide greater stability throughout the upper extremity kinetic chain. A molded arm-brace with shoulder cap is best suited for cases of complete brachial plexus injury, but each case must be considered individually. In cases of partial brachial plexus injury when sensory loss is not a major factor, prescription may follow the lines already described with relation to poliomyelitic paralysis. Where there is serious hypoesthesia or anesthesia of the hand, however, a hook is almost always necessary.

3. Spastic paralysis with good sensation but altered space perception (brain damage)

Patients in this group are the hardest to help. Very careful evaluation is needed. Paralysis is often associated with uncontrollable tremor, and the shaking may be touched off or intensified by use of the extremity. Although in many cases paralysis is not complete, the motor power remaining is so poorly governed by voluntary control as to be useless for function. Sensation is also decreased although not absent. Severe brain damage with changes in normal affect is a frequent concomitant. Motivation is often most superficial.

More important than the loss of motor power is the loss of space perception and association. The body image is damaged, and the patient does not remember that his hand is closed unless he watches it, and thus he will drop objects entrusted to it un-

less he is very careful. In treating arms affected by uncontrolled tremor, our first thought was that the arm should be stabilized throughout to control the unwanted motion that occurred on attempted use, but it became apparent that this was not the right thing to do. The additional apparatus extending over the shoulder and elbow did not completely control the tremor. Its cumbersomeness, taken together with poor voluntary control, prevented accurate placement of the terminal device. For these reasons it was discarded except for the handihook, this being operated from the opposite shoulder through an axillary or humeral loop. As the handihook is used in the patient's lap or on a table in a fixed position, use of it does not call into play the process that touches off the tremor. Because of associated persistent wrist flexion, a wrist splint is usually provided with the hook. From a functional point of view, the hook becomes a holding device so that the other hand may work against the hook-held object. We have no experience with cerebral palsy hemiplegia, but feel that the situations here are quite similar to those of brain damage and the cerebral vascular accident.

4. Quadriplegic paralysis with altered sensation but no disturbance of space perception as seen in cord injuries

In this condition normal sensation is seldom retained and the handihook, unilateral or bilateral, operated by a shoulder harness, should be the logical choice. However, it is interesting to note that rarely does a person with quadriplegic paralysis continue to use hooks, even though he learns to use them easily and well. This probably is because the level of function remaining equals the increased dexterity minus the level of gadget tolerance.

Tenodesis splints are more acceptable when sufficient motor power and sensation remain. This may be because the retained functional level is above the hook level.

5. Segmental loss of bony continuity where external brace support spans the bony defect

This, in our experience, is limited to the humerus, and here the brace is often rejected, depending on the work needs of the patient. It is difficult to bridge effectively from the scapula to the forearm without any telescoping of the upper arm and still preserve maximum function. In the most successful case in our experience the patient had to settle for a fixed elbow position to accomplish function for a limited task.

Franklin Hospital, Fourteenth and Noe, San Francisco 14 (Schottstaedt).

REFERENCES

1. Schottstaedt, E. R., and Robinson, G. B.: Functional bracing of the arm, Part I, Bone and Joint Surg., 38A:477-499, June 1956.

2. Schottstaedt, E. R., and Robinson, G. B.: Functional bracing of the arm, Part II, Bone and Joint Surg., 38A:841-856, July 1956.